

# **Acid - Base**

What You Need To Know

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# Introduction

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- What tests do we use?
- **ABG and Electrolytes**
- What is acidemia vs acidosis?
- What is acidemia?
- **pH < 7.35**
- What is Alkalemia?
- **pH > 7.45**

# Introduction

- What is an anion gap?
- Difference between the serum anions that are measured in a chemistry profile and the unmeasured anions
- What is the normal anion gap?
- $12 \pm 2$
- How do you calculate the anion gap?
- $\text{Na}^+ - (\text{Cl} + \text{HCO}_3)$

# The ABG

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- pH | pCO<sub>2</sub> | pO<sub>2</sub> | O<sub>2</sub> Saturation

## a-A gradient

- Room Air: 140 - (pCO<sub>2</sub> + pO<sub>2</sub>)
- Oxygen:

# ACIDEMIA

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# Respiratory Acidemia

## Metabolic

### Respiratory

**Acidosis**

$\text{HCO}_3^- < 24$

$\text{PCO}_2 > 40$

**Alkalosis**

$\text{HCO}_3^- > 24$

$\text{PCO}_2 < 40$

# Anion gap Acidosis

## “MUDPILES”

- **M** ethanol
- **U** remia
- **D** iabetic Ketoacidosis, Ketoacidosis
- **P** araldehyde
- **I** ron, Isoniazid (INH)
- **L** actic Acidosis
- **E** thanol, Ethylene glycol
- **S** alicylates

# Signs and Symptoms Gap Acidosis

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- **Drunk off their \_\_\_\_**
- **Hx of drug use**
- **Fruity breath**
- **Kussmaul's breathing**
- **tinnitus**
- **hypotension**



# Laboratory Workup

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- **Chemistries**
  - BUN, Cr, glucose
- **Lactate level**
- **Ketones**
- **Ethanol level**
- **Salicylate level**
- **Osmolal gap**
- **UA**

# Osmolar Gap

**Normal ( $< 25\text{mOsm/kg}$ )**

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- **Uremic Acidosis**
- **Lactic Acidosis**
- **Ketoacidosis**
- **Salicylates**

# Increased ( $>25\text{mOsm/kg}$ )

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- **Ethylene Glycol**
  - Look for Oxalate crystals in the Urine
- **Methanol Intoxication**
  - Visual Changes

# Treatment

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- **Treat underlying condition**
- **Remember:**
  - Methanol
  - Ethanol
  - Ethylene Glycol
  - Salicylates
- **Can Be Removed via Dialysis**

# Non gap Acidosis

## “HARDUPS”

- **H** yperalimentation
- **A** cetazolamide, amphotericin
- **R** TA
- **D** iarrhea
- **U** reteral Diversions
- **P** ancreatic fistula
- **S** aline resuscitation

# Is There Intestinal Fluid Loss?

**IF YES THINK About**

- **Ileostomy**
- **Diarrhea**
- **Enteric Fistula**

# Is there Intestinal Fluid Loss?

IF **NO**: What is the urine pH?

- if  $> 5.5$ 
  - Type I RTA
- if  $< 5.5$ , then **CHECK Potassium**
- if K is low = RTA type II
- if K is High = RTA type IV

**gap?**

# What is the cause?

- **P** araproteinemias, Multiple myeloma
- **L** ithium intoxication
- **E** xcessive Calcium and Magnesium
- **A** lbumin is low (hypoalbuminemia)
- **B** romism



# **Metabolic Alkalosis**

## **Chloride responsive**

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- **Volume Contraction:**
  - NG suction
  - Vomitting
  - Diuretics
- **Post Hypercapnia**
- **Hypokalemia**
- **Hypomagnesemia**
- **Carbenicillin, Penicillin**

# **Metabolic Alkalosis**

## **Chloride Unresponsive**

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- **Adrenal Disorders**
  - Glucocorticoid Excess
  - Mineralcorticoid Excess
- **Exogenous Steroids**
- **Alkali Ingestion**
- **Licorice**
- **Bartter's Syndrome**

# **Metabolic Alkalosis**

## **Signs and Symptoms**

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- **Muscle cramps**
- **Weakness**
- **Hypoxia**
- **Arrhythmias**

# **Metabolic Alkalosis**

## **Treatment**

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- **Volume repletion**
- **Correct Electrolytes**
- **Spirolonactone (hyperaldo)**
- **Treat Underlying process**

# **Respiratory Acidosis**

## **Differential Diagnosis**

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- **Pulmonary Disease**
  - Pneumothorax
  - Effusion
  - COPD
  - ARDS
  - PE
  - Inappropriate Vent setting

# Respiratory Acidosis

## Differential Cont'd

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- **Musculoskeletal Disease**

- Guillain Barre
- Myasthenia gravis

- **CNS**

- Sedatives
- Trauma
- Infxn
- Neoplasm

# Respiratory Acidosis

## Treatment

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- **ADEQUATE VENTILATION**

# **Respiratory Alkalosis**

## **Differential Diagnosis**

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- **Pulmonary Disease**
  - Pulmonary Edema
  - Pneumonia
  - PE
  - Inappropriate Vent settings
- **Why?**



# Respiratory Alkalosis

## Differential cont'd

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- **CNS**

- Increased Respiratory drive
- Infection
- CVA
- Trauma
- Anxiety

- **Drugs**

- Salicylates
- Catecholamines

# **Respiratory Alkalosis**

## **Differential cont'd**

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- **Sepsis**
- **Fever**
- **Pregnancy**
- **Liver Disease**
- **Anemia**
- **Carbon monoxide poisoning**

# Respiratory Alkalosis

## Treatment

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- **TREAT UNDERLYING CAUSE**

# APPROACH TO ACID BASE

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# Approach to Acid Base

**1.** Is the patient acidemic ( $<7.35$ ) or alkalemic ( $>7.45$ )

**2.**

	Metabolic	Respiratory
<b>Acidosis</b>	$\text{HCO}_3^- < 24$	$\text{PCO}_2 > 40$
<b>Alkalosis</b>	$\text{HCO}_3^- > 24$	$\text{PCO}_2 < 40$

# Approach to Acid Base

## Continued

### 3. Confirm pH is appropriate for (H<sup>+</sup>)

$$(H^+) = 24 \times pCO_2 / HCO_3$$

pH	7.1	7.2	7.3	7.4	7.5
7.6					

H <sup>+</sup>	78	62	50	40	32
25					

Look to Facts and Formulas

# 4. Calculate the Anion Gap

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- **Calculate the Anion Gap:  
(normal is 12 +/- 2)**
- **If AG is >20 then primary metab gap acidosis is present regardless of pH**

# Compensated Appropriately

**met acidosis**      expected  $p\text{CO}_2 = 1.5(\text{HCO}_3) + 8$

**met alkalosis**      expected  $p\text{CO}_2 = .9(\text{HCO}_3) + 9$

**Acute resp acid**      each increase in  $p\text{CO}_2$  of 1,  
pH should decr by .008

**Acute resp alk**      each decrease in  $p\text{CO}_2$  of 1,  
pH should incr by .008

**Chronic resp acid**      each increase in  $p\text{CO}_2$  of 1,  
pH should decr by .003

**Chronic resp alk**      each decrease in  $p\text{CO}_2$  of 1,  
pH should incr by .003



# 6. The Triple Disorder

## Calculate the Delta Gap

- If **AG** acidosis is present: to determine if other underlying condition present
- Take the change in AG =  $(AG - 12)$
- Add to  $HCO_3$ 
  - ie  $(AG - 12) + \text{Serum } HCO_3$
- if **<23** = non gap acidosis
- if **>30** = metabolic alkalosis

# EXAMPLES

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# Examples

## 1 - 3

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**1.** 7.38 | 64 | 146 | 98.8%

Na 146, K 3.7, Cl 105, CO<sub>2</sub> 35

**2.** 7.39 | 65.1 | 62 | 90.6%

Na 145, K 4.3, Cl 104, CO<sub>2</sub> 35

**3.** 7.50 | 34.7 | 58 | 92.4%

Na 143, K 3.6, Cl 107, CO<sub>2</sub> 25

# Examples

## 4 - 6

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**4.** 7.32 | 50 | 65 | 95%  
Na 140, K 3.5, Cl 102, CO<sub>2</sub> 25

**5.** 7.49 | 34.3 | 121 | 98.6  
Na 145, K 3.5, Cl 108, CO<sub>2</sub> 26

**6.** 7.41 | 30 | 82 | 96.4  
Na 141, K 3.7, Cl 98, CO<sub>2</sub> 23

# Examples

## 7 - 9

**7.** 7.36 | 46.4 | 175 | 99.1  
Na 143, K 4.1, Cl 106, CO<sub>2</sub> 25

**8.** 7.36 | 50.4 | 166 | 99.0  
Na 140, K 2.9, Cl 95, CO<sub>2</sub> 25

**9.** 7.27 | 44.2 | 159 | 98.8  
Na 138, K 3.5, Cl 97, CO<sub>2</sub> 18

# Examples

## 10 - 12

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**10.** 7.495 | 29.8 | 72 | 95.9  
Na 137, K 4.1, Cl 95, CO<sub>2</sub> 22

**11.** 7.38 | 39.1 | 77 | 95.2  
Na 139, K 3.9, Cl 99, CO<sub>2</sub> 21

**12.** 7.42 | 38 | 60 | 92  
Na 135, K 4.5, Cl 101, CO<sub>2</sub> 22

# Examples 13

**13.** 7.40 | 30 | 78 | 96.4

Na 147, K 4.0, Cl 15, CO<sub>2</sub> 12

# **Diabetic Ketoacidosis**

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# Symptoms of DKA

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- **Nausea / Vomitting**
- **Frequent urination**
- **Thirst -- excessive**
- **Abdominal pain**
- **SOB**
- **Drowsiness**
- **Stupor**
- **Unresponsiveness**

# Signs of DKA

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- **Hypotension**
- **Tachycardia**
- **“fruity” breath**
- **Kussmaul’s respirations**
- **Orthostasis**

# Abnormalities of DKA

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- **Glucose >300**
- **Serum Bicarbonate <15 mEq/L**
- **pH <7.30**
- **Anion gap acidosis**
- **Electrolyte abnormalities**
  - increased potassium

# Diabetic Ketoacidosis

## Treatment

- **VOLUME up to 5 - 6 liters**
  - over 2 hours
  - add 5% dextrose when BG < 250 (**why?**)
- **INSULIN**
  - 10 units bolus then
  - 5-10 units per hour IV continuous infusion
- **CORRECT ELECTROLYTE ABNORMALITIES**
  - Hyperkalemia

# Diabetic Ketoacidosis

## Treatment

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- **BICARBONATE**
  - When to administer??
- **When do you stop the Insulin Infusion?**
- 8-12 hours after anion gap resolved and ketonuria cleared

